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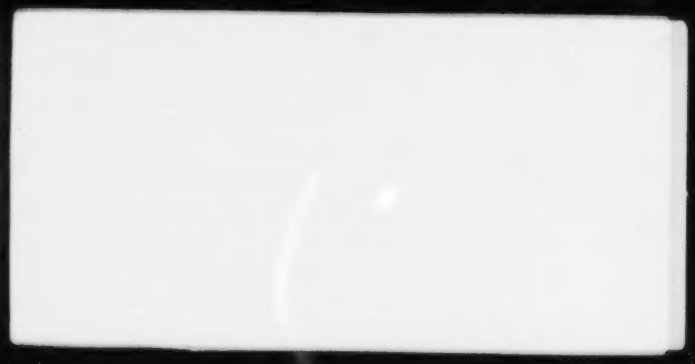

DEFENCE AND CIVIL INSTITUTE OF ENVIRONMENTAL MEDICINE

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EFFECT OF ALCOHOL ON CONTRAST SENSITIVITY

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Table of Contents

ABSTRACT 2
INTRODUCTION 3
Background 3
Present Study 3
METHOD 4
Subjects 4
Apparatus 4
Procedure 4
RESULTS 6
DISCUSSION 9
CONCLUSION 9
REFERENCES 10

ABSTRACT

This study examined the effect of alcohol on contrast sensitivity at normal levels of illumination. Contrast sensitivity was measured, using the Vistech VCTS 6500 Test Charts, on two groups - an alcohol group with peak Blood Alcohol Concentration (BAC) levels of 0.12% and a placebo group. Both groups were assessed prior to ingestion of alcohol, at the peak BAC of the alcohol group and at five one hour intervals following peak BAC. There were no differences in contrast sensitivity between the two groups at peak BAC. The results were in keeping with previous research that suggests that alcohol does not affect initial sensory processing.

INTRODUCTION

Background

The results of many studies assessing the effect of alcohol on visual functioning suggest that alcohol does not affect low-order sensory processing of visual information. For instance, alcohol has been shown to have no effect on static visual acuity (1) or peripheral vision (2). In the latter study, it was found that alcohol produced an impairment in peripheral vision only when the subject was forced to divide attention between two competing tasks. As long as the subject could focus attention on the peripheral vision task, alcohol did not impair performance on that task. Thus, alcohol would appear to be affecting primarily central processing.

However, the finding that the locus of the alcohol effect is at higher levels of information processing is inconclusive because of limitations to the construct validity of the measures of visual capabilities that were used. For example, Brown, Adams, Haegerstrom-Portnoy, Jones and Flom (1) suggested that dynamic visual acuity may be a more valid test of vision than static acuity since the former was found to be correlated with driving accident records. In that study, they found that dynamic visual acuity was affected by alcohol consumption. In looking at the effect of alcohol on visual capability, it would appear preferable to employ tests of vision that are predictive of performance on complex visual tasks such as driving.

In recent years, contrast sensitivity has gained acceptance as a valid measure of visual capability (3,4). Contrast sensitivity measures a person's ability to detect low contrast stimuli (frequently sinewaves) at various spatial frequencies. It has been shown to be correlated with detection of aircraft in a simulator (5), and in the field, (6) and with age related differences in sign discrimination (7). In all these studies, Snellen acuity, one of the most common methods used to assess vision, did not predict differences in performance.

Only a few studies have examined the effect of alcohol on contrast sensitivity. Adams and Brown (8) found that alcohol increased the time required to recover foveal contrast sensitivity after exposure to glare. They used small circular targets to measure contrast sensitivity. A later study (9) using larger discs found no effect. Sekuler and MacArthur attributed the original results to mislocalization of the disc arising from the use of small discs. More recently, the effect of alcohol on contrast sensitivity has been examined using standard test charts (10). Unfortunately, it is difficult to draw clear conclusions from this study because the Blood Alcohol Concentration (BAC) levels of the seven subjects ranged from 0.02% to 0.13% and there was no control group. Although the study concluded that alcohol degraded contrast sensitivity, the data showed both improvements and decrements in contrast sensitivity at peak BAC and as BAC decreased.

Present Study

The present study examined the effect of alcohol on contrast sensitivity measured under normal room illumination. Contrast sensitivity was measured on two groups - an alcohol group with peak BAC levels of 0.12% and a placebo group. Both groups were assessed prior to ingestion of alcohol, at the peak BAC of the alcohol group and at five one hour intervals following peak BAC.

METHOD

Subjects

The subjects were 20 paid male volunteers between the ages of 19 and 30 selected from respondents to newspaper advertisements. They were selected on the basis of a drug use questionnaire to eliminate regular users of psychoactive drugs as well as both light and heavy drinkers as defined by the Cahalan, Cisin and Crossley quantity-frequency scale of alcohol use (11).

Subjects were required to undergo a medical examination to ensure they were medically fit and were not taking any medication. During the physical examination, each subject's weight and skinfolds (at the triceps, the sub-scapular and supra-iliac sites) were measured to permit calculating lean body mass.

Apparatus

Contrast sensitivity was measured using the Vistech VCTS 6500 Test Charts. (Figure 1 illustrates one of the three charts used in the study). The stimuli presented on the charts are pictures of sinusoidal gratings. Each row consists of a sample grating at a high contrast and eight test gratings. The contrast of the test gratings range, in approximately 0.3 $\log_e$ unit steps, from contrasts that are above the visual threshold to contrasts that are usually below the threshold of the normal observer. The ninth grating has zero contrast. Spatial frequency is constant within rows, and changes from row to row. At the recommended viewing distance of 305 centimeters (10 feet), the spatial frequencies displayed are 1.5, 3, 6, 12, and 18 cycles per degree (cpd). The gratings are aligned -15, 0 or +15 degrees from the vertical. Each grating pattern subtends a visual angle of 1.4 degrees at the recommended viewing distance.

Blood alcohol concentration (BAC) was measured using an Alcohometer breathalyzer, model AE-D1. The digital readout provided BAC readings accurate to within ± 5 mg/l.

Procedure

A mixed double blind design with one between factor (alcohol treatment) and one within factor (trials) was used. Twenty subjects were divided into two groups of ten, a placebo group and an alcohol group.

Subjects fasted for 12 hours prior to arriving at the laboratory. During the course of the test day, they completed seven trials, each consisting of a breathalyzer reading and a contrast sensitivity test.

Contrast sensitivity was measured using the recommended procedure for the charts. The charts were located in a room in which the light falling on the charts was within the recommended range of 30 to 70 footlamberts (100 to 240 candelas/m^2).

Before the first test, the procedure was explained to the subjects using the instructions provided with the charts. Subjects stood 305 centimeters from the charts. For each spatial frequency, the subject stated the orientation of the bar pattern starting with the left most grating pattern. If the contrast was too low to determine the orientation, they could respond "blank". During each trial, the chart used was randomly selected from a set of three.

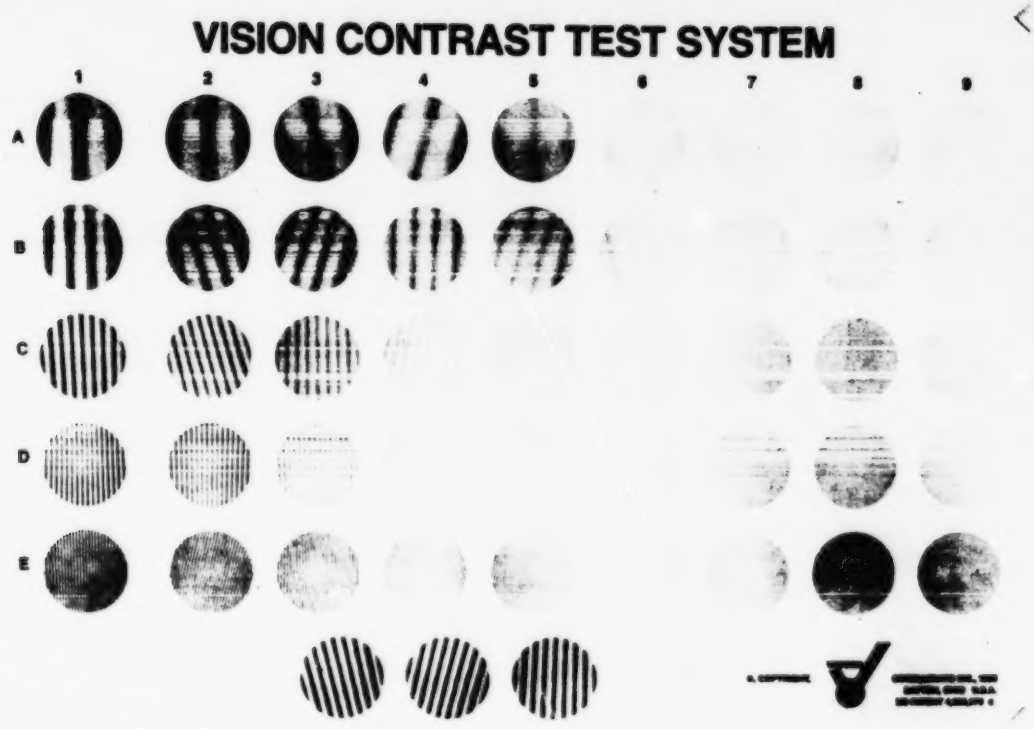

FIGURE 1: An example of one of the Vistech VCTS 6500 Test Charts. Three different versions of the chart were used to assess contrast sensitivity.

The first trial was carried out prior to treatment to establish a baseline. The subjects were then taken to an adjacent lounge for treatment. The alcohol treatment was in the form of three equal strength "screwdrivers" with a total alcohol content of 3.475 ml of alcohol per kilogram of lean body mass. The alcohol was diluted with orange juice mix in the ratio of 1:1.67. This amount of alcohol was calculated, taking into account the kinetics of distribution and elimination, to be the amount required to produce a peak blood alcohol concentration of 1200 mg/l or 0.12% at 25 to 30 minutes after consumption. Based on previous research experience, this was the highest level to which subjects could be dosed without excessive discomfort or risk. The placebo treatment consisted of three drinks of straight orange juice with an eyedropperful of vodka floated on the top just prior to serving. Subjects received one drink every 20 minutes. After the third drink had been consumed, they were given a 30 minute rest period. Then, at what was predicted to be peak BAC, the second test was carried out. Five more test trials followed at hourly intervals.

Between trials, the subjects were allowed to relax in an adjacent lounge. A light lunch was served between the third and fourth trial. At the completion of the last trial, the subjects' BACs were measured to ensure that they were below 0.03%, and they were driven home.

Throughout the test, precautions were taken to prevent adverse reactions and to ensure subject comfort. Subjects were never left unsupervised and a physician remained on call at all times. Only two subjects reported significant discomfort.

RESULTS

The methodology followed to insure equivalent and predictable BAC levels appeared to be successful. The average BAC for the 10 subjects in the alcohol group was 0.119% 30 minutes after ingestion of the alcohol. BAC dropped at the rate of 0.02% per hour after that point.

The measure of contrast sensitivity used was the reciprocal of the contrast of the rightmost grating pattern that the subject identified correctly at each spatial frequency. Modulation contrast is calculated as the maximum luminance of the sinewave grating minus its minimum luminance divided by the sum of the two luminances. The top panel of Figure 2 shows that the average baseline contrast sensitivity for the two groups was similar. The standard deviations of the two groups were similar as well, ranging from 0.1 $\log_e$ units at 1.5 cpd to 0.4 $\log_e$ units at 18 cpd.

The remaining panels show the contrast sensitivity of the two groups at peak BAC (trial two) and in the final trial (trial seven). As can be seen, average contrast sensitivity of the alcohol group at peak BAC did not differ from that of the placebo group. The standard deviations for these trials were similar to those for the baseline measure. The third panel shows the contrast sensitivity of the two groups in trial seven. While there appears to be a difference between the two groups, with the alcohol group having higher contrast sensitivity especially at the middle spatial frequencies, an analysis of variance carried out on the data from trial seven indicated that the differences between the two groups did not reach significance ($F = 3.7$; $df = 1, 17$; $P < 0.08$).

In addition to comparing the two groups across trials, the baseline contrast sensitivity of each group was compared with their contrast sensitivity in the remaining trials. Figure 3 shows the average differences across subjects between baseline contrast sensitivity and contrast sensitivity in trials two through seven. All of the data have been expressed in $\log_e$ units to equate differences across the different spatial frequencies. As Figure 3 indicates, the shifts in contrast sensitivity across trials at the different spatial frequencies are similar and random for the two groups. The exception is trial seven where the contrast sensitivity of the alcohol group is always at least 0.1 $\log_e$ units better than the baseline level at all spatial frequencies. An analysis of variance was carried out on the differences across trials within each group and spatial frequency. The only significant difference across trials was for the alcohol group at 6 cpd ($F = 6.5$; $df = 6, 54$; $P < 0.01$).

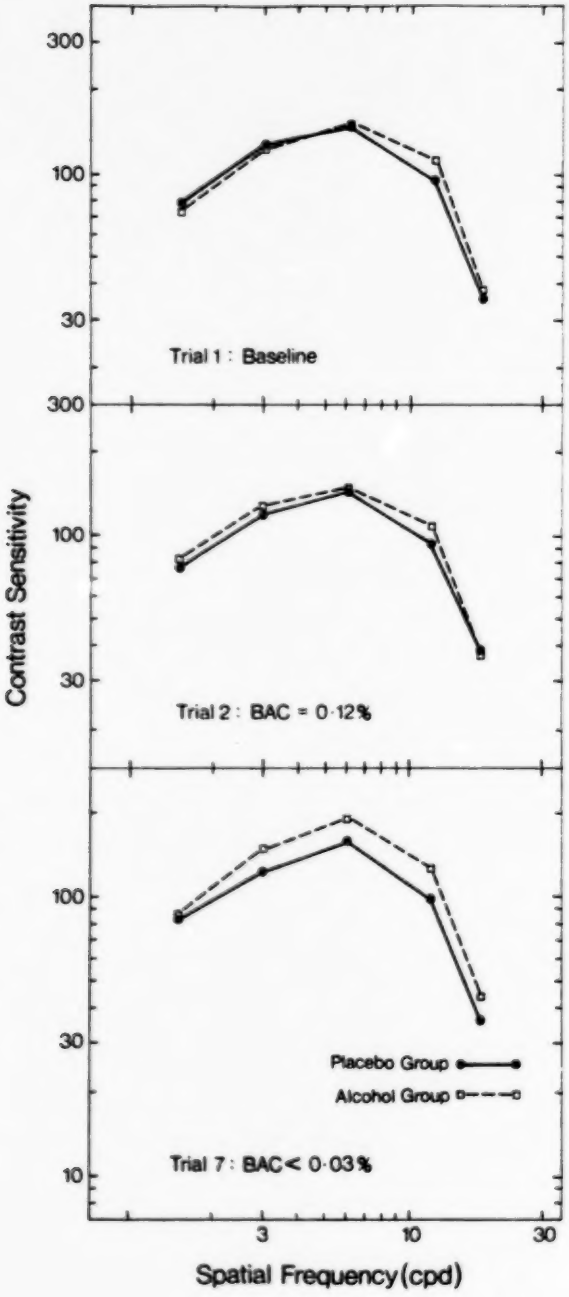

FIGURE 2: Average contrast sensitivity of alcohol and placebo groups on trials one, two and seven.

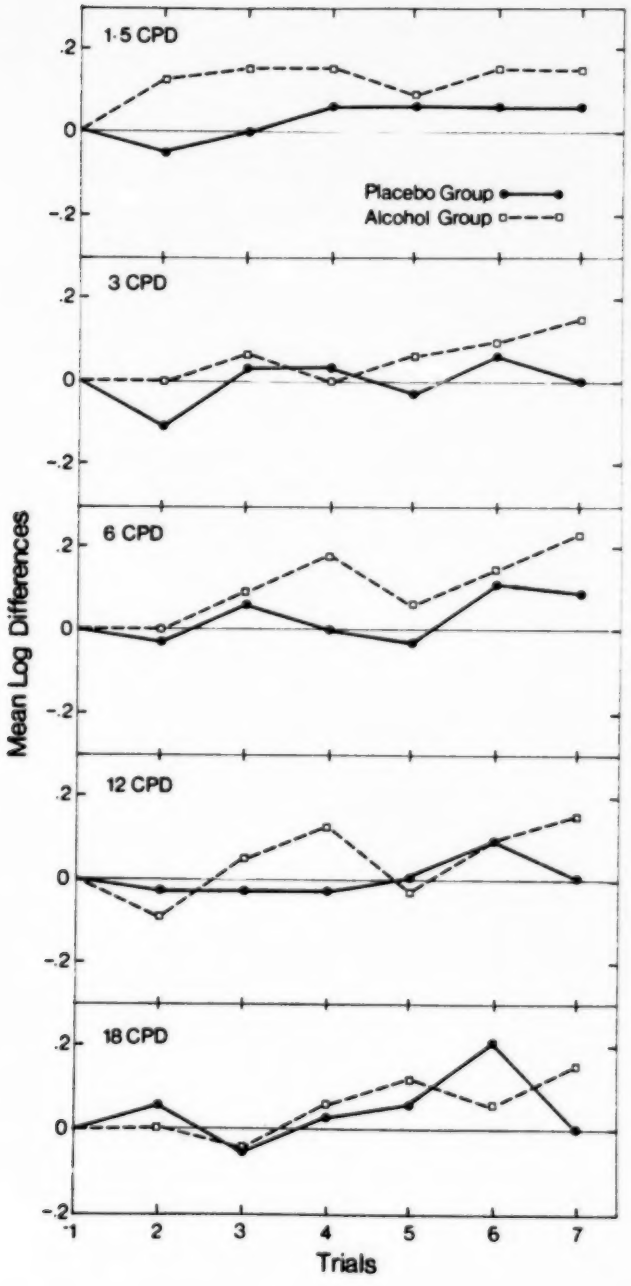

FIGURE 3: Mean log differences in contrast sensitivity between trial one and each successive trial at each spatial frequency.

DISCUSSION

Based on these results, there is no evidence that alcohol degrades contrast sensitivity, at least under the conditions tested. These results appear to differ from those found by Ginsburg et al. (10). However, after examining their data in detail, the results of the two studies were not dissimilar. Ginsburg et al. looked at the effect of alcohol on contrast sensitivity under three illumination levels (3, 0.3 and 0.03 fL). At 3 fL, the shifts in contrast sensitivity between the no alcohol and the peak alcohol trials were similar to this study. At the two lower levels of illumination, the shifts in contrast sensitivity were much larger, but they were still observed to move in both directions. Thus, their data appear to offer little support for their conclusion that alcohol degrades contrast sensitivity.

The only significant effect was the improvement in contrast sensitivity across trials at 6 cpd. This finding is consistent with the small but insignificant improvement found on trial seven at all spatial frequencies. One possible explanation of the improvement is that it is a physiological response to a prolonged state of heightened BAC, for example, the dehydration that often accompanies ingestion of alcohol. Dehydration could reduce the water film that is normally found on the cornea which could affect the contrast of objects with their background (12).

The effect of alcohol on contrast sensitivity was investigated because of recent research which shows that contrast sensitivity is correlated with performance on complex visual tasks such as target acquisition (5-7). Thus, if alcohol affected contrast sensitivity, that would provide some evidence that at least part of the effect of alcohol in real world tasks could be due to an impairment of low-order sensory processing. The results of this study support those of previous studies (2, 9) which concluded that alcohol does not affect the early stages of visual processing.

The data from the placebo group, in addition to providing a control for the alcohol group, permitted analysis of the reliability of repeated contrast sensitivity measures over the course of a day. The contrast sensitivity of the placebo group shifted between 0.1 and 0.2 $\log_e$ units or about one dB over the course of the seven trials. This is less than the difference between two successive grating patterns on the charts which is about 0.3 $\log_e$ units or 2 dB. Moreover, the shifts were random. There was no evidence of an improvement in contrast sensitivity across trials. At each spatial frequency, approximately 10 to 20% of the subjects shifted up and an equivalent percentage shifted down relative to the first trial.

CONCLUSION

The results of this study provide no evidence that alcohol degrades contrast sensitivity under normal levels of illumination. The shifts in contrast sensitivity found for a group of subjects with peak BAC levels of 0.12% were small and equivalent to the shifts found with a placebo group. If, as suggested (4), contrast sensitivity does predict performance on real-world tasks, then the results of this study are further evidence for the contention that the effect of alcohol on the performance of complex visual tasks is not due to a degradation in low-order sensory processing.

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